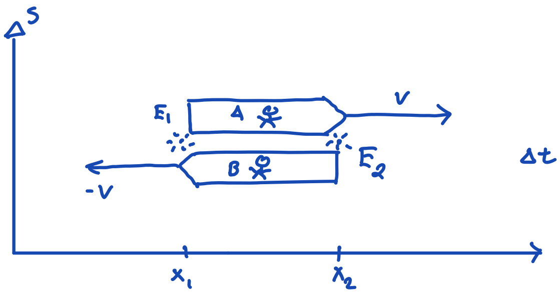
Simultinaeity

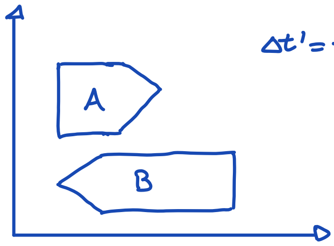
Simultinaeity is Relative!
If two events happen in 1 I.R.F, they are generally not simultaneous in another



$\Delta t = t_2 - t_1 = 0$

A: Sees E_2 first (moving toward)
B: Sees E_1 first (moving toward)
} Both are correct

Consider the events from S.S. B RF
Space Ship A is length contracted

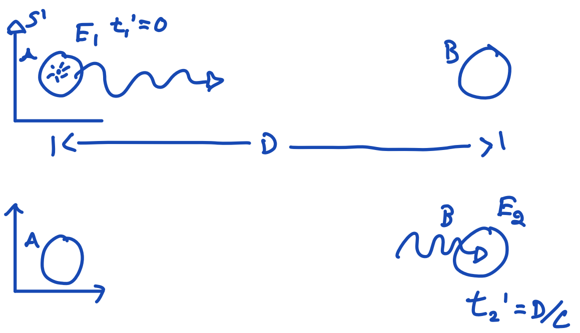


$\Delta t' = t_2' - t_1' > 0$

Clock Synchronization in a Single I.R.F

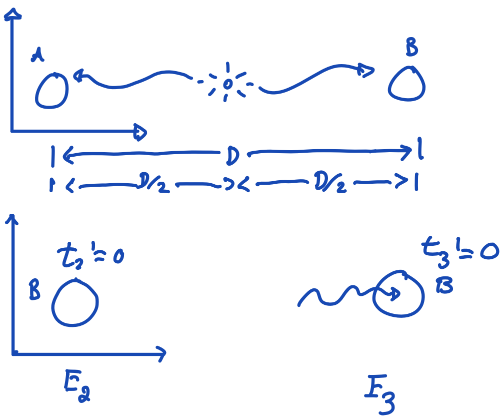
- Clocks Synchronized in 1 I.R.F are not Synchronized in another!

To synchronize clocks in an I.R.F . . . .



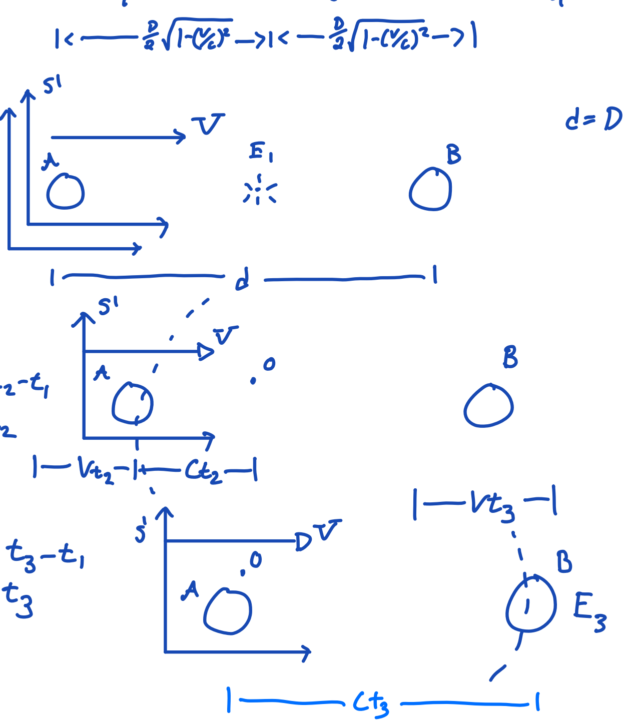
Clocks will be Synchronized

OR . . . .



The moving Object

- Let the synchronized clocks in S' move w speed V relative to S . . . .



$d = D\sqrt{1-(V/c)^2}$

$\Delta t_{12} = t_2 - t_1$
$= t_2$

$\Delta t_{13} = t_3 - t_1$
$= t_3$

E_1: A lightbulb is flashed $t = t_1$
E_2: Light reaches A's moving clock $t = t_2$
E_3: Light reaches B's moving clock $t = t_3$

Notice

$$\frac{d}{2} = \frac{D}{2}\sqrt{1-(V/c)^2} = Vt_2 + Ct_2 = (C+V)t_2$$

$$\Delta t_{21} = t_2 = \frac{D\sqrt{1-(V/c)^2}}{2(c+V)}$$

$$\Delta t_{31} = t_3 = \frac{D\sqrt{1-(V/c)^2}}{2(c-V)}$$

The time difference between the 2 events, according to S is.....

$\Delta t = t_3 - t_2$

From P2:

$\frac{D}{2}\sqrt{1-(v/c)^2} = (v+c)\,t_2 \qquad \therefore\ t_2 = \frac{D\sqrt{1-(v/c)^2}}{2(c+v)}$

$\frac{D}{2}\sqrt{1-(v/c)^2} = (c-v)\,t_3$

$t_3 = \frac{D\sqrt{1-(v/c)^2}}{2(c-v)}$

The time difference according to the S observer

$$\Delta t_{32} = t_3 - t_2 = \frac{D\sqrt{1-(v/c)^2}}{2}\left(\frac{1}{c-v} - \frac{1}{c+v}\right) = \frac{D\sqrt{1-(v/c)^2}}{2}\left[\frac{(c+v)-(c-v)}{(c-v)(c+v)}\right]$$

$$\frac{Dv\sqrt{1-(v/c)^2}}{c^2\left(1-(v/c)^2\right)} = \frac{Dv}{c^2}\,\frac{1}{\sqrt{1-(v/c)^2}}$$

Clocks in S' runs slow according to S, So the time difference of S', according to S, is....

$$\Delta t' = \Delta t\sqrt{1-(v/c)^2} = \frac{Dv}{c^2}\cdot\frac{1}{\sqrt{1-(v/c)^2}}\cdot\sqrt{1-(v/c)^2} = \frac{Dv}{c^2}$$

notice $\Delta t' \neq 0$

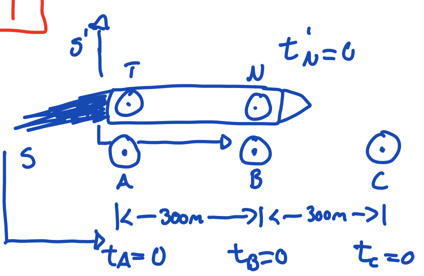
when clock B reads $t_B' = 0\,s$ Leading clocks lag

Clock A reads $t_A' = \frac{vD}{c^2}$

Three Rules

1. Moving clocks run slow by $\sqrt{1-v^2/c^2}$
2. Moving objects are contracted by $\sqrt{1-v^2/c^2}$
3. Two clocks Synced in own Frame will not be Synced in other Frames
   leading clocks lag by $\Delta t' = vD/c^2$

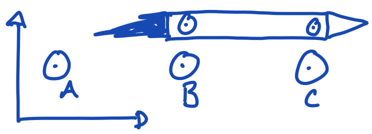
Samp 1



$d_{NT} = D_{NT}\sqrt{1 - v^2/c^2} = 500\,m\,(3/5) = 300\,m$

S' - S.S

S - Ground



$D_{NT} = 500\,m$ $\quad t_A = 375\,m/c \quad t_B = 375\,m/c \quad t_c = 375\,m/c$

$V = 4/5\,c$

a.) $\Delta t' = \frac{vD_{NT}}{c^2} = \frac{4}{5}c\left(\frac{500\,m}{c^2}\right) = 400\,m/c$

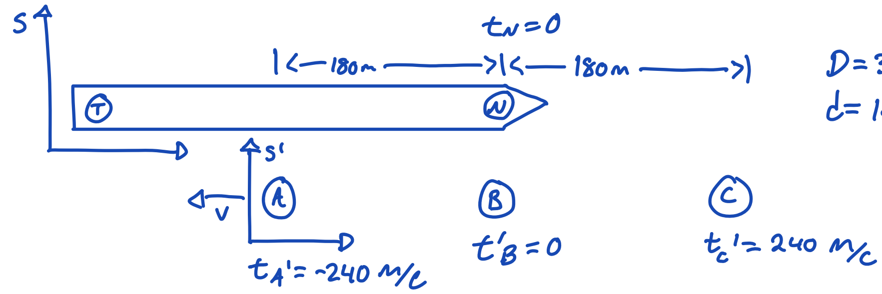
$\frac{400\,m}{3.0\times10^8\,m/s} = 1.3\times10^{-6}\,s$

b.) $V = \frac{D_{NT}}{\Delta t} \quad \therefore\ \Delta t = \frac{D_{NT}}{v} = \frac{300\,m}{4/5\,c} = 375\,m/c$

c.) $\Delta t' = \Delta t\sqrt{1-v^2/c^2} = 375\,m/c\cdot\frac{3}{5} = 225\,m/c$

$t_N' = 225\,m/c$

$t_T' = 625\,m/c$



$D = 300m$
$d = 180m$

$$\Delta t' = \frac{v D_{AB}}{c^2} = \frac{\frac{4}{5}c\,(300\,m)}{c^2} = 240\ m/c$$

According to the S frame $\Delta t = \frac{D_{NT}}{v} = \frac{500m}{4/5\,c}$

$\Delta t = 625\ m/c$

$D_{AB} = D_{BC} = 300\,m$

$D_{NT} = 500m$

$\Delta x' = 0 \quad \therefore \Delta t = \frac{\Delta t'}{\sqrt{1 - v^2/c^2}} \quad \therefore \Delta t' = \Delta t\sqrt{1 - (4/5)^2}$

$= 625\ m/c\ (3/5) = 375\ m/c$

When tail at B

$t_A = -240 + 375 = 135\ m/c$

$t_B = 0 + 375 = 375\ m/c$

$t_C = 240 + 375 = 625\ m/c$